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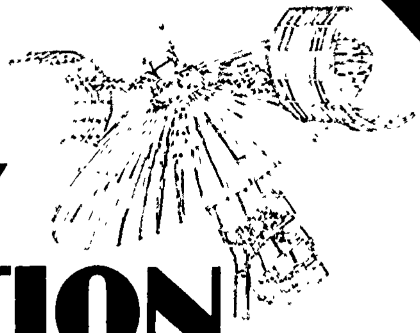
ABSTRACT

The VHF system used by the Satellite Technology Demonstration had a built-in digital response system to collect data about student programing. This paper describes the hardware and software required to implement and operate the system. In addition, information on the applications of this device is provided along with the results of a field experiment in which junior high school students used the system. A general description of the VHF is presented as a necessary background for the description of the limited digital response. The details of the data collection also are presented. Finally, the applications and results of the system are given. (Author/EMH)

SATELLITE TECHNOLOGY DEMONSTRATION



FEDERATION OF ROCKY MOUNTAIN STATES, INC.

technical report

TR0426

LIMITED DIGITAL RESPONSE

DENNIS LAURENCE WILLIAM WOUGHTER

ABSTRACT

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INTRODUCTION

The Health, Education, Telecommunications (HET) experiment, a series of projects sponsored by HEW and NASA, was developed to demonstrate how present satellite communications technology can be used to increase available health and education opportunities in less-populated regions. The HET network involved the use of color video, voice, and data communications.

The video material was distributed via a NASA satellite, the ATS-6. With the exception of a few sites in Alaska, the video communications was one-way to the remote sites. Two-way voice and data communications were provided via VHF links (through the NASA satellites ATS-1 and ATS-3) to selected sites in the network.

VHF COMMUNICATIONS SYSTEM

The VHF system can be described best by first explaining the remote equipment, then showing how the Network Coordination Center communicated with the remote site. The following description is not comprehensive, but provides a brief background for this report.

Remote Terminal

The remote terminal was a VHF installation that was physically separate from, and independent of, the video microwave receiving equipment used for the color television portion of the HET network. The major elements of this terminal included: (1) a helical antenna and its associated equipment; and (2) an indoor terminal including a transmitter, receiver, and digital control device, known as a "digital coordinator."

The digital coordinator sends and receives digitally-coded words for the purposes of remote control, identification, and/or data transfer. Its basic mode of communication employs a sequence of five words--referred to as a "preamble"--that are sent out before each transmission originating at a remote site. Encoded in the preamble are identification of the site and information relating to the mode of operation (e.g., call, voice, or data). Preambles were sent to remote HET sites to configure the sites for various operational modes. Since each site had a unique "address", it was possible to "command" each site individually. Provisions were made for sending blocks of data from the remote site to the Network Coordination Center by transmitting the appropriate number of words in a continuous serial stream. In addition, external devices, such as teletypes, could be used with the system.

Due to link parameters, transmitter size, and terminal complexity, the remote sites transmitted PSK encoded data and received FSK encoded data. When properly configured, the VHF equipment could be used for normal, two-way voice communications.

Network Coordination Center

All data communications in the HET network were designed to take place between the Network Coordination Center (NCC) and the remote terminals, whereas voice communications could take place between remote sites, NASA, and NCC.

At NCC, a computer was used as the main communications and control device for transmitting, receiving, and processing all data traffic. The computer monitored all incoming preambles and, through display devices, indicated the status of the network. The NCC operators controlled the network by feeding instructions to the computer, which then sent the proper command signals to the remote sites via the earth station facilities.

LIMITED DIGITAL RESPONSE KEYPAD SYSTEM

The limited digital response system refers to an "add-on" device to the digital coordinator described above. It was so-called because it allowed a limited amount of data to be sent from a remote site to the NCC computer for processing. The hardware included: (1) a single printed circuit card that fit into the digital coordinator; (2) an unregulated power supply; and (3) up to 28 keypads.

The keypad shown in Figure 1 is a device similar in appearance to a small desk calculator. The pad has 12 keys, a single numerical indicator, and three lamps. Data was entered into the pad one digit at a time and displayed on the readout. Data entered into the keypads was sent over the VHF link to the NCC computer through an NCC-controlled polling process. This system had various modes of operation, depending on the application.

Hardware

The touchtone "keypad" was designed to be used in a classroom with students. The case and keys minimized possible damage due to tampering or accidental spillage of liquids. When one keypad was required, a single cable connected it with the digital coordinator. For multiple keypads, the units were connected in a loop. This arrangement reduced the cabling required, making a suitable arrangement for classroom use.

The cabling arrangement was made possible by the use of a parallel data buss: the data from each pad was collected on the same signal lines, one at a time. Each keypad in the system was given a unique address so that the data gathered and sent to the NCC was directly correlated to the individual keypads. Another feature of this system was that the cables had individual connectors, allowing the keypads to be removed and replaced easily in case of a failure. The connectors were internal to the case to prevent students from disconnecting them.

The keys on the pad were 0-9, *, and #. The asterisk is equivalent to the number 10, but it was displayed on the readout as an A. The number sign is equivalent to the number 15 and displayed on the readout as an F. These symbols were used because the actual data system operated on the hexidecimal number system, but the readout was designed for the decimal number system.

In addition to the keys and readout, there were three red LED indicator lamps corresponding to "ready," "right," and "wrong." These indicators were used to provide positive feedback to the person using the keypad.

The printed circuit card (shown in Figure 2), which contained the electronics to operate the keypads was called the "poller." This card plugged into the digital coordinator; the keypad cable plugged into the poller. All controls for the poller were in the digital coordinator and were activated through commands from the NCC. The operator-user at the remote site needed only to turn on the equipment and enter data at the appropriate times; no other operator input was required.

The poller contained the circuitry that generated the keypad addressed in sequence--thence, the name poller. As each keypad (or keypad location if no pad was connected) was addressed, the data from that pad was transferred to the digital coordinator and sent to the NCC. If no pad was connected, the data was recognized as decimal 15. The poller went through the address sequence twice, as a redundant transmission, to help reduce the error rate.

The poller also contained a "memory" that allowed data to be stored for future transmission. This was used for the multi-digit mode discussed in detail in the following section. To address positions in memory, the poller was configured to use its address generator, rather than keypad addresses. This mode of operation allowed a series of digits to be entered (one at a time) from a single pad and later be transferred back to the NCC. In addition to the address generator and memory, the poller contained the circuitry used to light the "ready," and "wrong" lamps--according to the mode and application.

Power for the poller was taken from the digital coordinator. The digital coordinator's power supply was sufficient to operate one keypad, but operation of multiple keypads required an external power supply.

Operation

Basic operation was achieved through commands sent from the NCC to the remote terminal in question. This system operated over a single channel, making it necessary to coordinate the activities so that only one site was polled at a time. In addition, depending on the use

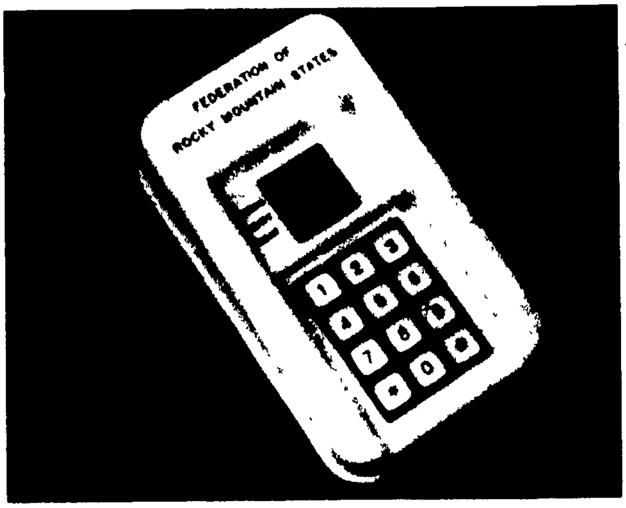

Figure 1. Keypad

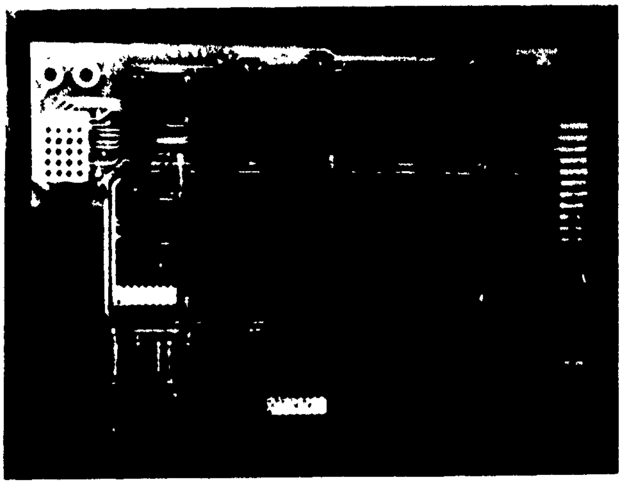

Figure 2. Poller

of the system, it usually was necessary to synchronize the polling process with events occurring on the television screen.

All data sent back from the remote sites was received directly by the computer; therefore, processing of the data occurred in real time for either immediate display or analysis. It was easy to vary the computer software to allow operation in various modes and with different applications.

The hardware was designed for operation in three basic modes which are discussed below. These modes were chosen with a particular application in mind; therefore, some information on applications also is given below.

Single Pad Multi-Digit Mode

The single pad multi-digit mode of operation used a single keypad and the poller memory to collect and send back a series of up to 28 digits. This mode was used to send back site data concerning reception quality to the NCC.

Procedures were set up to format the data so that operators at both the remote site and the NCC would understand the significance of each digit in the series. It was neither required nor necessary to use all the digits. The actual process was as follows:

1. The NCC operators initiated a set of commands through the computer to configure the remote terminal for the multi-digit mode.
2. At the remote site, the "ready" lamp would light, indicating that the data could be entered into the keypad.
3. The operator (using the keypad) entered the data, one digit at a time, until all data was entered.
4. The NCC operator, after allowing sufficient time for Step 3, initiated a command that caused the data then in the memory to be sent back to the NCC.
5. This process was repeated for each site.

When this system was used for more than one remote site, Step 1 was initiated for all the sites, before going on to Step 2. Then the computer was able to poll all the sites in rapid succession (Step 4).

Answer Returned Reinforced Learning Mode

The answer returned reinforced learning mode--a programming aid--was designed to be used in a classroom with students. A group of keypads enabled each student to have his/her own pad. The format of the data was similar to the multi-digit data, except that each digit in the series of digits sent to the NCC represented data from a specific keypad. It was not necessary to use all 28 keypads; if a keypad was not used, the digit would always come back as a 15.

The answer return was a unique and interesting feature that was built into this mode of operation. The system used in this mode enabled students to answer multiple-choice questions sent over the video program. The command which was sent from the NCC to cue the remote site to start the polling process was encoded with the correct answer. The correct answer was compared to the answer the student had selected, and the "right" or "wrong" lamp was illuminated accordingly. The actual process was as follows:

1. The NCC operator initiated a set of commands through the computer to configure the remote terminal for the answer-return mode.
2. At the remote site, the "ready" lamp would light, indicating that data could now be entered into the keypads.
3. The students entered the answer (one digit) into their keypads.
4. The NCC operator, after allowing sufficient time for Step 3, initiated a command containing the correct answer that caused the data in the keypads to be sent back to the NCC.
5. The keypads were "locked" with the answer the student had selected, along with the right or wrong indication, for approximately 15 seconds. The right/wrong indicator light then went out, and the keypad was set to wait for the next "ready" indicator.
6. The process was repeated for each remote site.

This system, like the multi-digit mode, could be operated to poll a group of sites in rapid succession.

Opinion Polling Mode

The opinion polling mode was very similar to the answer-back mode, but the "right"/ "wrong" indication was not used. Operation was the same as the Steps indicated above, with the following exceptions:

1. In Step 4, the correct answer was not sent out, and no right/wrong indication on the keypads occurred.
2. Step 5 was eliminated as there was no need to "lock" the keypads.

APPLICATIONS

As indicated in the previous sections, the limited digital response system was designed for two general applications. These two areas were: (1) as a real time data acquisition system; and (2) as an aid to educational television. The first technique used the single pad multi-digit mode of operation, and the second technique used the answer-back and opinion polling modes. These applications were the primary ways in which the limited digital response system was used in the HET experiment and have been discussed, in detail, in the following sections. Future planners should note, however, that there are many more applications that have potential for future investigation and use.

Use as a Real Time Data Acquisition System

The requirements for a real time data acquisition system are presented first, then the means by which the keypad system can not only meet these needs but also provide additional benefits are presented.

The ATS-6 used for distribution of the video programs to the remote sites, provided coverage to limited geographic areas, known as "footprints." There were two footprints provided by the ATS-6. These footprints were moved to provide coverage to the various areas in the United States. The pointing of the antenna on the satellite determined where the footprint would be located on the earth's surface. Pointing was important to insure that the signal strength at the remote sites would be adequate for high-quality video reception.

To verify that the pointing was correct, information--indicating video quality and signal strength--was sent to NASA immediately prior to each transmission. This information then was used to determine if the pointing was correct or if other problems were present. It was important to collect the preprogram information in a real-time mode and then to relay it to NASA before the actual program began. Due to time constraints necessary for effective program scheduling, the time allowed for this activity sometimes was limited to less than five minutes.

The method originally established for collecting preprogram data was the two-way voice/data link discussed in the section titled "VHF Communications System." The procedure was to poll each site, one at a time, using the voice channel and to ask for the information. Although this procedure was adequate most of the time, two major problems occurred with voice polling: (1) the site operator was required to "stand by" at the remote terminal and wait to be polled; and (2) the process consumed too much time.

To correct these problems, a limited digital response system was used with this system:

1. The site operator gathered the information and entered it into the pad, then proceeded with other tasks. The polling was automatic, so the operator was not required to stand by.
2. The actual polling process--taking less than one second for each site--was faster than using the two-way voice data link.
3. The NCC operators were free to perform other tasks, since the input required from the operators was minimal. Manual recording of the information was not required.
4. The computer software was set up to make the go, no-go decision based on analysis of the data sent in.

This collection system is not limited to collecting only preprogram information. It also can be used to collect data for a variety of uses in a communications system, such as the HET network.

Use as an Aid to Educational Television

The limited digital response system, when used to provide a link from the television audience back to the origination point, provided a unique capability for television audiences. This capability made it possible to obtain information from the viewer prior to, during, and after a video presentation, without interrupting either the video or audio programs. In addition, there was the added dimension of active learner participation in the otherwise passive television viewing.

Either the learning reinforced or opinion mode of operation was employed when the limited digital response system was used as an aid to educational television. The learning reinforced mode provided cognitive measurements of each student's comprehension of the video program. The opinion mode helped to evaluate overall acceptance of the programming, as well as student desire for participating in the Demonstration.

To investigate the educational applications of the system, the equipment was installed and used in an actual classroom situation. The following information describes the equipment set-up, the objectives of the experiment, and some conclusions and results.

The system was set up at the Saratoga Junior High School (in Wyoming) and was used in conjunction with career education programs sent over the ATS-6 The students had been viewing the career education programs throughout the school year. Two-way voice interaction was used during a portion of the program set aside for this activity and was coordinated from the origination point.

The basic setup for the Experiment was as follows. First, the keypads were set up so that 12 students had their own pads. The rest of the class was used as a control group. Second, questions were asked via a character generator overlayed on the video presentation. The students were allowed to respond, and the data was collected at the NCC. Third, due to the need to synchronize the polling process with the video program and the questions, the entire process was controlled from the computer at the NCC.

The educational objectives for this application were:

1. To monitor and reinforce the student's acquisition of career-related knowledge on an immediate or continuing basis.

2. To involve the student and teacher in an active response to presented materials for measures of learning and acceptance as a result of interactive participation.
3. To determine the effects of active responses on the student's acceptance, cognition, and desire for participation.
4. To investigate the relative effectiveness of various visual and audio presentation formats in enhancing interactive responses.

In view of the above objectives, certain questions arose that were related to this system in the classroom. These questions were:

1. What are the effects of interrupting an audio/visual presentation to take cognitive and affective measurements?
2. Can viewers provide affective responses collected simultaneously with their viewing of a program?
3. What happens when the keypads are placed in the hands of students?

The first question was concerned with asking for specific judgments from a viewer during a program and interrupting the acquisition of the intended messages. The second question dealt with asking viewers to judge the program on a scale which indicated degrees of "like" or "dislike" as the program progressed. The third question was concerned with whether the students would be distracted by the keypads.

RESULTS

Effects of Interrupting the Video Program

This experiment used two groups of students to determine whether the act of answering questions during a program had an effect on the cognition or acceptance of the program. The limited digital response system was used for students to answer both cognitive and acceptance questions during a program. The control group was asked the same questions using Optical Mark Read (OMR) cards after viewing the program.

The results were as follows:

1. The students using the keypads made higher scores on the cognitive questions and showed more positive acceptance of programming than students who did not use pads.
2. The students using the keypads paid closer attention to the programs than the students who did not use the pads.
3. When using the learning reinforcement mode, a cheer or verbal expression usually was emitted by the student when verification of a correct response was given.
4. No noticeable distraction was caused by interrupting the program; interruptions seemed to come at natural "attention-span breaks."

Effects of Making Affective Judgments During a Program on Cognition and Acceptance

This experiment used two groups to investigate a situation similar to the situation described for interrupting video programs. This time, however, the students were asked only to use the system in the opinion mode. The students indicated changes in their evaluation of the programs, as they viewed the programs. This activity differed from the previous experiment in that specific questions were not asked during the program. The cognition of the students was evaluated in the same way as in the previous experiment.

The results indicated that the activity required for affective judgments by the student did not hinder the obtaining of the program material. Program segments that tended to "drag out" or that were "uninteresting" easily were identified by the students' responses.

General Conclusions

The experiments indicated that the limited digital response contributed to the student's comprehension and interest in television programs. Question-and-answer periods during a program did not appear to distract the student, but actually increased his/her attention to the program. The presence of the hardware did not result in any intentional destruction of the equipment. Further, the system effectively demonstrated one of the most innovative methods of insuring that: (1) the students' acquisition of knowledge was monitored and reinforced on an immediate and continuing basis; and (2) that all students in a learning situation were involved in the Demonstration through participation and interaction.

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